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ATOMS AND ISOMORPHISM

Our knowledge of the nature of atoms has recently been enlarged in a remarkable way with many important results, some of which were quite unforeseen.

Atoms were formerly known only by their weights and chemical properties. They are now believed to consist of a nucleus and one or more electrons, which together occupy a measurable portion of space. Formerly the properties of atoms were held to be related to the atomic weights. I shall try to show that one of the properties of atoms depends upon their sizes rather than their weights.

The measurement of the sizes of atoms is one of the important results of recent studies of crystals by the new method with X-rays. W. H. and W. L. Bragg[1] reflected X-rays from crystal faces and found that the angle at which reflection became evident bore a simple relation to the wave-length of the X-rays used and to the distance between adjacent layers of atoms in the crystal. The validity of the equation: $\lambda = 2d \sin \alpha$ is easily demonstrated by means of Fig. 1, if it be remembered that the intensity of reflection from a single layer of atoms is extremely small, and the reflected ray only becomes appreciable in case reflections from many parallel planes of atoms are in phase and therefore reenforce each other.

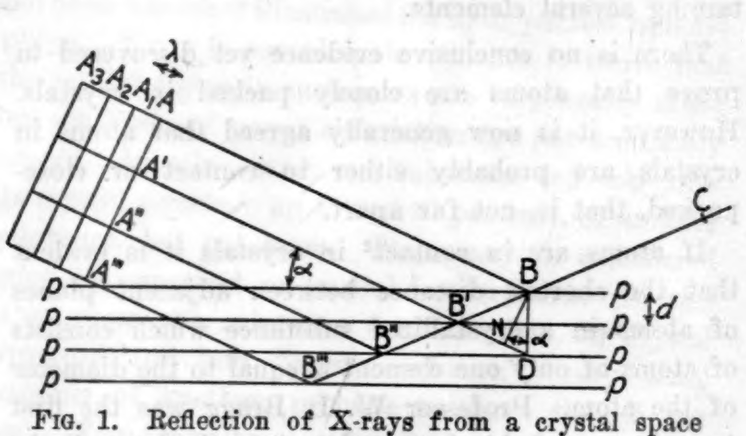

Fig. 1. Reflection of X-rays from a crystal space lattice (after Bragg).

Accordingly, the distance (d) between adjacent planes of atoms is equal to the wave-length (λ) of the X-rays divided by twice the sine of the angle of incidence (α). The wave-lengths of X-rays from various sources are now quite accurately known. Therefore it is only necessary to measure the angle of incidence at which reflection occurs in order to be able to calculate the distance between adjacent planes of atoms in any crystal.

[1] "X-Rays and Crystal Structure."

Dimensions of Atoms

Atomic "radii" according to W. L. Bragg (*Phil. Mag.* 40, 1920, p. 161) and calculated atomic domains (Angstrom units)

At. No.	Element	Radius	Volume	At. No.	Element	Radius	Volume
3	Lithium	1.50	14.	28	Nickel	1.35	10.
4	Beryllium	1.15	6.4	29	Copper	1.37	11.
6	Carbon	0.73	1.9	30	Zinc	1.32	9.7
7	Nitrogen	0.65	1.2	33	Arsenic	1.26	8.4
8	Oxygen	0.65	1.2	34	Selenium	1.17	6.8
9	Fluorine	0.67	1.3	35	Bromine	1.19	7.
11	Sodium	1.77	23.	37	Rubidium	2.25	48.
12	Magnesium	1.42	12.	38	Strontium	1.95	31.
13	Aluminum	1.35	10.	47	Silver	1.77	23.
14	Silicon	1.17	6.8	48	Cadmium	1.60	17.
16	Sulphur	1.02	4.5	50	Tin	1.40	12.
17	Chlorine	1.05	4.9	51	Antimony	1.40	12.
19	Potassium	2.07	37.	52	Tellurium	1.33	9.8
20	Calcium	1.70	21.	53	Iodine	1.40	12.
22	Titanium	1.40	12.	55	Cæsium	2.37	56.
24	Chromium	1.40	12.	56	Barium	2.10	39.
25	Manganese	1.47	13.	81	Thallium	2.25	48.
26	Iron	1.40	12.	82	Lead	1.90	29.
27	Cobalt	1.37	11.	83	Bismuth	1.48	13.

In this way the exact arrangement of the atoms in nearly all crystallized elements has been accurately determined. The same method has given similar data for many crystallized binary compounds and for a few crystallized ternary substances. The problem becomes much more difficult of solution with increasing complexity of composition, but important progress is being made even with substances containing several elements.

There is no conclusive evidence yet discovered to prove that atoms are closely packed in crystals. However, it is now generally agreed that atoms in crystals are probably either in contact or close-packed, that is, not far apart.

If atoms are in contact[2] in crystals it is evident that the shortest distance between adjacent planes of atoms in a crystallized substance which consists of atoms of only one element is equal to the diameter of the atom. Professor W. L. Bragg was the first to make use of this fact, and to compile from all the known data a table of the diameters (or radii) of the atoms, as shown below, and graphically in Fig. 2.

Present theories of an atom picture it as composed of a nucleus surrounded by one or more shells of electrons; they therefore permit the assumption, as a first approximation, that atoms are nearly spherical in shape. If so, the approximate volume of any atom can be calculated easily from the table of diameters and the formula: $V = 4/3\,\eta R^3$. In this expression the "volume" is intended to denote not a portion of space solidly occupied by the atom, but that portion of space required for its existence, which is doubtless equal to all the space within the outermost shell of electrons. Some writers have called this volume the atomic "domain" and Tutton has named it the "sphere of impenetrability."

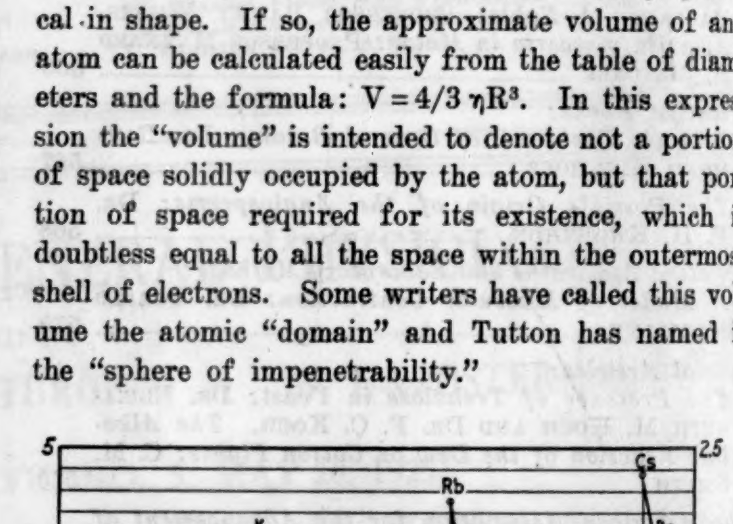

FIG. 2. Atomic domains of elements (after Bragg).

The size, volume or *domain* of an atom is the newly discovered physical property whose importance is

[2] If atoms are packed closely together in crystals, but are not in contact, the "volumes" of various atoms, as obtained from the "diameters" or "radii," are slightly greater than the true volumes of the atoms, but represent correctly the portions of space required for the existence of the atoms in crystals.

not yet appreciated by many scientists. It is not supposed to be absolutely constant, like the atomic weight, but, if variations occur under varying physical conditions, they probably do not exceed 25 or 30 per cent., and may be assumed to affect all atoms in about the same way, so that, relatively, the different kinds of atoms vary still less in size.

It is important to note that the atomic domains are not proportional to the atomic weights, but in any series (of the periodic classification) decrease with increasing weight, and, in general, show the same periodic relation to the weight as do all other physical and chemical properties, as shown in Fig. 2. In general, the atoms of electronegative or acid elements are much smaller than those of electropositive or metallic elements. Atoms of the same group (of the periodic classification) are not of the same size, but increase in size with increase of weight. In any series the size decreases with increasing valence.

In the study of crystals it was long ago learned that they are composed of units which are definitely and uniformly arranged throughout a single crystal. Indeed, the precise number of possible types of crystals was determined many years before all these types were found, by a mathematical solution of the problem of finding all possible arrangements of points in space such that the arrangement about any one point is the same as (or else a mirror image of) the arrangement about any other point. Nearly all solid mineral substances are crystalline, so that this condition of very exact arrangement of the units in a solid is the normal state of substances which are not liquid or gaseous. Any given substance solidifying under given conditions always produces crystals of exactly the same kind. It is a natural consequence of the precise arrangement of the units of structure in crystals that they are bounded by smooth faces; and, furthermore, that the angles between similar faces are exactly the same on all crystals of the same kind. Finally, with some exceptions, the interfacial angles of any substance are different from those of any other substance. This is so true that the great Russian mineralogist, Federoff, has recently published elaborate crystallographic tables[3] by means of which he has been able to completely identify many substances by crystal measurements alone.

However, some substances form crystals whose angles differ only slightly from those of the crystals of certain other substances. Two substances whose crystals are nearly the same in shape are said to be "isomorphous," which means that they are characterized by having the same forms. This term "isomorphism" was applied to such a condition when it was supposed that the forms were exactly the same; it is now demonstrated that they differ, though the difference may be very slight.

Substances which form crystals of almost exactly the same shape are nearly always closely related in chemical composition. For example, the following substances illustrate four isomorphous groups:

I	II	III	IV
$CaCO_3$	$CaSO_4$	$MgFe_2O_4$	$MgFe_2O_4$
$MgCO_3$	$SrSO_4$	$FeFe_2O_4$	$MgAl_2O_4$
$FeCO_3$	$BaSO_4$	$ZnFe_2O_4$	$MgCr_2O_4$
$MnCO_3$	$PbSO_4$	$NiFe_2O_4$	
$ZnCO_3$			

It was a natural conclusion from these and similar facts that in an isomorphous series only those changes of composition are possible in which one element replaces another of the same valence.

In the light of our new knowledge of the precise structure of crystals this conclusion needs revision, as I shall attempt to show in the following discussion.

Isomorphism is a comprehensive term, which is generally understood to apply to all cases of chemically similar substances which have similar crystal forms. No one has ever defined the amount of chemical or crystallographic similarity necessary to constitute isomorphism. However, it is generally agreed that intercrystallization to form homogeneous crystals composed of two (or more) substances in any proportions whatever illustrates the most perfect isomorphism. There is considerable evidence to prove that the crystal forms in such cases are very nearly alike, but the limits of possible variation are not accurately known. In other cases one substance can take into its crystal structure up to say 40 per cent. of another substance, but not more. These may be considered cases of imperfect or partial isomorphism. In still other cases one substance can take into its crystal structure (or into "crystal solution") very small amounts of another, perhaps no more than 5 per cent. These may be considered cases of very limited isomorphism.

Reverting to the X-ray study of crystals, it may be recalled that such studies have led to the conclusion that crystals are built of atoms which are in contact, or close packed. Furthermore, in any crystal each kind of atom occupies certain definite positions, so that, for example, a crystal of NaCl consists of atoms of Na in a definite arrangement intergrown with atoms of Cl in a definite arrangement, as shown in Fig. 3. Such definite arrangements of atoms, whether of one kind or several kinds, are known as "space lattices." That is, the NaCl space lattice con-

[3] Memoire Acad. Sci. Russie, Phys. Math. ser. 8, XXXVI, 1920.

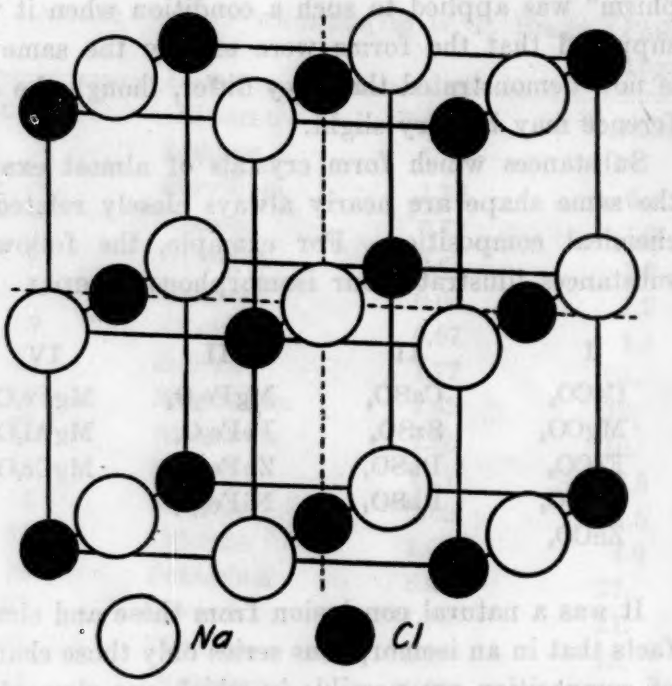

FIG. 3. Space lattice of sodium chloride.

sists of two parts—a regular space lattice of Na atoms intergrown with a regular space lattice of Cl atoms. Neither one of these space lattices can exist alone, but, if it could, it would make a crystal of the same type and symmetry as the interpenetration of the two, and just as perfect a crystal, except for the voids occupied in the NaCl crystal by the atoms of the other space lattice. If any atoms other than those of Na or Cl exist in a NaCl crystal (not merely mechanically enclosed) they must either replace some of the atoms of the NaCl space lattice, or be small enough to find places between these, as very fine sand can find places between the grains of very coarse sand, even though the latter are in contact. Both these cases probably occur in crystals, but it is plainly only the first case which can lead to an isomorphous series. For example, if a NaCl crystal contained some NaBr, not mechanically mixed, but as an integral part of the crystal, the Na space lattice would not be changed at all, but the Cl space lattice would be different in that some of the points occupied by Cl atoms in a pure NaCl crystal would be occupied by Br atoms. With a gradual increase in the relative number of Br atoms a series can be imagined extending from pure NaCl to pure NaBr.

In general, all crystals, whose detailed structure is now known, are similar to those of NaCl in consisting of two (or more) interpenetrating space lattices. Any one of these is just as definite and regular as any other.

Now, if crystals are close-packed space lattices built out of atoms, and if isomorphous systems can be formed only by replacement in the space lattice of one kind of atom by another, it is evident that the size (or domain) of the atoms must be very important in determining what atoms can mutually replace one another in such systems. This principle, that atoms must be of nearly the same size in order to be able to form isomorphous systems in various compounds, seems to be far more important than the old idea that the atoms must be of the same valence. In every substance forming a crystal or an end-member of an isomorphous system all valences must be satisfied, but it does not follow from this that the replacing atoms must be of the same valence. For example, in feldspars, $NaAlSiSi_2O_8$ and $CaAlAlSi_2O_8$ are end-members of a perfect isomorphous series in which Na and Si of the first substance are replaced by Ca and Al of the second. That is, a monovalent and a tetravalent atom are replaced by a divalent and a trivalent atom. This leads to a complete isomorphous series, because the volumes of Na and Si are nearly equal to the volumes of Ca and Al.

The feldspars also illustrate the point that size of atoms is more important than equal valences or other chemical similarities. Thus, $NaAlSi_3O_8$ and $KAlSi_3O_8$ are two well-known feldspar molecules which differ only in one atom—Na or K—and the change here is from one alkali to another alkali element of the same valence and similar chemical characters. Nevertheless, $NaAlSi_3O_8$ and $KAlSi_3O_8$ exhibit only imperfect or partial isomorphism,[4] while $NaAlSi_3O_8$ and $CaAl_2Si_2O_8$ form a perfect isomorphous series.

Similar conditions seem to exist in every group of isomorphous minerals[5] which is fully known. Thus, in the garnet group there are six end-member molecules which belong to two systems,[6] rather than one, as follows:

[4] It is an interesting fact that, in this case and in some others, two substances, whose unlike atoms differ so much in size that the isomorphism is only partial at ordinary temperature, exhibit perfect isomorphism at high temperature, as if the expansion of the space lattice due to heat were sufficient to permit free replacement of the smaller atoms by larger ones at high temperature, even though that is impossible at low temperature.

[5] An apparent exception is presented in the case of the zeolites (and certain other hydrous minerals) which are capable of exchanging bases with those of salts in a solution in which they are immersed under the control of valence and independent of the size or number of the atoms concerned. The writer believes that this is possible only *after formation* of the crystals and that atomic volume relationships are in control during the formation of the crystals in this case as in the case of all anhydrous minerals. He has presented the evidence for this view in the *American Mineralogist*, Vol. X, 1925.

[6] H. Boeke: *Zeit. Krist.*, LIII, 1914, p. 149.

I	II
$Ca_3Al_2(SiO_4)_3$	$Mg_3Al_2(SiO_4)_3$
$Ca_3Fe_2(SiO_4)_3$	$Fe_3Al_2(SiO_4)_3$
$Ca_3Cr_2(SiO_4)_3$	$Mn_3Al_2(SiO_4)_3$

The members of each system are mutually miscible (in crystals) in all proportions, since Al, Fe and Cr are similar in size, and also Mg, Fe and Mn, but the members of one system show only partial miscibility with members of the other system, since Ca has nearly twice the volume of Mg, Fe or Mn.

Again, in the calcite group, which consists of $CaCO_3$, $MgCO_3$, $FeCO_3$ and $MnCO_3$, $CaCO_3$ is not miscible in more than very limited amounts with any of the other substances, and the latter are mutually miscible in all proportions, on account of the unequal size of Ca as compared with the other—nearly equal—bases. $CaCO_3$ forms double salts with the other molecules, but these are not evidence of miscibility, since they have entirely different symmetry; even if they were considered evidence of miscibility, $CaCO_3$ could not be considered miscible with the other molecules except in certain quite limited ranges of proportions, and not in all proportions, like the other molecules of the group.

Many isomorphous groups of natural silicates are only imperfectly known, and the true explanation of the variations in their composition, that is, the exact formulas of the end members of the systems, are still under discussion. This is not the place even to summarize such discussions, and I am therefore forced to assume responsibility for my statements in such cases, rather than to pursue the more satisfactory method of presenting the evidence.

In the melilite group of minerals the chief molecules are:[7] $Ca_2MgSi_2O_7$ and $Ca_2Al_2SiO_7$, while other molecules include $Ca_2FeSi_2O_7$, $Ca_2Fe_2SiO_7$, $Ca_2MnSi_2O_7$, $Ca_2ZnSi_2O_7$, and probably $Ca_3Si_2O_7$ and $Na_2Si_3O_7$. All these molecules, except the last two, seem to be mutually miscible in all proportions. According to the results of experiments made here last year by Wanenmacher and Kyle $Na_2Si_3O_7$ is miscible in $Ca_2MgSi_2O_7$ to about 30 per cent., and $Ca_3Si_2O_7$ to about 5 per cent., or, in the presence of $Na_2Si_3O_7$, to about 20 per cent.

The nephelite group consists of $NaAlSiO_4$ and $KAlSiO_4$, with which $CaAlAlO_4$ seems to be miscible[8] in limited amount.

Melilite[9] and nephelite both seem to illustrate the second method by which foreign atoms can enter a space lattice. That is, both commonly contain a limited amount of excess SiO_2, which is demonstrably not essential to the crystal, and in one case has been shown to increase the specific gravity in proportion to its abundance.

The scapolite group[10] brings out one more point of importance. The chief molecules are: $NaCl.3NaAlSi_3O_8$ and $CaCO_3.3CaAl_2Si_2O_8$, which may also be written: $Na_4Al_3Si_3Si_6O_{24}Cl$ and $Ca_4Al_3Al_3Si_6O_{24}CO_3$. That is, Na and Si are replaced by Ca and Al as in feldspar, and also one atom of Cl is replaced by the CO_3 group. If the volume of the CO_3 group could be considered as equal to the sum of the volumes of the atoms concerned the total would be about the same as that of Cl, but *considered as a group* the volume of CO_3 is evidently much greater, and approaches 3/4 η times the cube of the sum of the radius of C plus the diameter of O. Therefore, it seems probable that in this case Cl is replaced by C and the extra oxygen atoms occupy interatomic spaces, like the atoms of SiO_2 in nephelite and melilite.

One more case must be mentioned. A. E. H. Tutton,[11] of England, has spent a lifetime making a series of crystallographic and optic measurements of extraordinary accuracy on sixty-two salts of the orthorhombic series $R_2(S, Se)O_4$ and the monoclinic series $R_2M(S, Se)_2O_8.6H_2O$, in which R represents K, Rb, Cs, Tl or NH_4 and M represents Mg, Zn, Fe, Ni, Co, Mn, Cu, or Cd. While all the substances in each group are isomorphous in the broad sense of that term, it is important to note that in this case also the extent of miscibility is determined by the relative sizes of the atoms concerned. Thus salts of K are miscible to a moderate extent with those of Rb, but only to a very slight extent with those of Cs. The volume of the NH_4 group is not accurately known, but it must be nearly equal to that of Rb, since Rb and NH_4 salts are miscible in all proportions.

Many other examples could be described, but perhaps more are unnecessary.

In summary, it may be said that, while substances which are chemically closely similar are often isomorphous in the broad sense of that term, the most perfect cases of isomorphism are found among substances which are chemically less closely related, because the relative sizes of the atoms determine the miscibility of substances in crystals, and the atoms which are chemically most nearly alike are not most similar in size.

A. N. WINCHELL

UNIVERSITY OF WISCONSIN

[7] *Am. Jour. Sci.* CCVIII, 1924, p. 375.

[8] The view that $CaAlAlO_4$ is a constituent of nephelite is new and not demonstrated, but it is in harmony with all known facts.

[9] *Am. Jour. Sci.* CCVIII, 1924, p. 375.

[10] Am. Mineral. IX, 1924, p. 108.

[11] "The Natural History of Crystals," London, 1924.

THE AWARD OF THE FRANKLIN MEDAL TO PROFESSOR ELIHU THOMSON[1]

It was with the keenest delight that I learned that Dr. Elihu Thomson had been selected to receive the Franklin Medal for this year, and I deeply appreciate the honor of being asked to participate in the happy event.

The secretary informs us that the award of the Franklin Medal to Dr. Thomson is "in recognition of his pioneer work in the field of electricity and electrical engineering and of his numerous inventions in these fields."

Fortunately, Dr. Thomson's achievements in the field of electricity are so well known that I need consume but a few minutes of your time to refresh your memories, or to indicate how wise and fitting has been the action of your committee in making this award.

Dr. Thomson has long been recognized as one of the world's great pioneers in the electrical field, and it is well known that his contributions have been continued from the pioneer days to the present time, so that, after fifty years of strenuous and fruitful effort, he is still recognized as a leader in his chosen field.

His inventions and engineering work have been the basis of a great manufacturing and engineering industry, and are set forth in some seven hundred United States patents, mostly relating to electrical subjects.

Dr. Thomson was a pioneer in the field of alternating current, and it is particularly interesting that in the Franklin Institute, in this very hall, at a series of lectures given in 1879, he exhibited an alternating current dynamo of his own construction from which he ran two transformers with fine wire primaries connected in parallel to the dynamo-line, and the secondaries performing the local work. This was the prototype of the modern transformer system.

This pioneer work was one instance of many where Dr. Thomson's ideas were years in advance of the world's readiness for their reception, and, recognizing this fact, he turned his attention to the development of a system of arc lighting.

His famous 3-coil arc dynamo, with its automatic regulator and other novel features, formed the basis of the successful lighting system put out by the Thomson-Houston Electric Company in the year 1880. This machine was remarkable for its simplicity, ruggedness, flexibiilty and efficiency. It was the first machine to be entirely automatic in its operation, and it would maintain an absolutely constant current flowing in a circuit over the extreme range from full load to a complete metallic short circuit—a feature possessed by no other machine at that time.

He was the first to utilize a magnetic field to move an electric arc. This idea took many forms and was first applied in 1881 in connection with a lightning arrestor for his arc light system. This principle was immediately extended to the construction of switches in which the magnetic field was used to interrupt the arc formed upon breaking a circuit. All of these devices, known as "magnetic blowout devices," were of fundamental importance and are still used on an extensive scale, notable applications being found in the controllers for electric street cars, electric trains for elevated roads, and on large electric locomotives.

Later, returning to the alternating current field, he was the first to use oil as an insulating material in transformers, and to make the high tension alternating current system safe for human beings by introducing the practice of grounding the secondaries of transformers and distributing circuits. In his notable discovery of the so-called alternating current repulsion phenomena, he laid the basis for commercially successful alternating current motors.

A patent granted in 1883 for a reactive coil clearly points out the distinction between a resistance and a reactance, and sets forth the practical value of the reactive coil in regulating and controlling alternating current circuits.

He made the first very high frequency dynamo in 1890, with a frequency about forty times higher than that hitherto produced in any dynamo. Shortly afterwards he originated the method of producing a high frequency alternating current from a direct current by shunting the arc with inductance and capacity, and published at the time a description of this beautiful apparatus and the theory of its operation.

He also made the first high frequency transformer, and, as a result of brilliant scientific investigations, developed apparatus which was afterwards utilized in wireless telephone and telegraph work.

His universal electric meter for recording direct and alternating current energy and his new electric measuring instruments of all kinds made possible that definite and accurate knowledge needed for the orderly growth of the electrical business.

But Dr. Thomson was not satisfied with even these great contributions to a developing art. In 1886 he gave us a new art—the art of electric welding by the incandescent method. This discovery and its development, spot or line welding, are used for a multitude of services, from the joining of fine wires which lead current into the incandescent lamp or the radio valve,

[1] Address by E. W. Rice, Jr., honorary chairman of the board of directors of the General Electric Company, previous to the presentation at the Franklin Institute on May 20.

the construction of the hulls of great steamships without rivets. Metals previously unweldable were easily joined, and complicated and expensive mechanical methods were made simple, cheap and reliable.

He made many important contributions to the field of radiology, and was the first to make stereoscopic X-ray pictures.

He did early pioneer work with the electric resistance furnace and developed a method of manufacturing that beautiful material, fused quartz, by electrical means, which gives every evidence of being the best yet devised.

He made the first important research into the nature of the laws governing the electric arc. The results of his investigation were published in the Franklin Institute Journal in 1879, and disclosed among other things the important fact that the resistance of the arc varied inversely with the current, which accounted for the instability of an arc unless operated from a circuit having constant current characteristics.

During the years since this first research he has made many other scientific researches to some of which I have briefly alluded, and has contributed hundreds of articles on scientific and engineering subjects.

This incomplete and imperfect sketch will, perhaps, serve to indicate the extent and variety of Dr. Thomson's knowledge and the range of his mental activities, and the ingenuity and great practical value of his work. He has not been content to make some astonishing discovery or invention and then lapse into comparative quietude, but during his entire life has been a continuous worker. Thomson, perhaps more than any other inventor since the days of Henry and Faraday, combines in his person profound and accurate scientific knowledge with most extraordinary technical skill.

He has received numerous honorary degrees, Master of Arts, Yale, 1890; Doctor of Philosophy, Tufts College, 1894; Doctor of Science, Harvard, 1909; Doctor of Laws, University of Pennsylvania, 1924; Doctor of Science, Victoria University, Manchester, 1924.

Dr. Thomson received the Grand Prix in Paris, 1889, and again in 1900, for electrical inventions, and was decorated by the French government as an officer of the Legion of Honor. In 1904 he received the Grand Prix at St. Louis. He was given the Rumford Medal in 1902, and in 1910 was the first recipient of the Edison Medal. In addition, he has been awarded the Elliott Cresson Medal, the John Fritz Medal, the Hughes Medal of the Royal Society, London, and last year the greatest of all English medals, the Kelvin Medal.

It would therefore seem singularly fitting that he should now be the recipient of the Franklin Medal, given by the Franklin Institute, the scene of his earliest pioneer work in the electrical field. It is with the greatest pleasure that I present to you Dr. Elihu Thomson for the receipt of the Franklin Medal.

WILLIAM JAMES BEAL: AN AMERICAN PIONEER IN SCIENCE

The student who now-a-days begins the study of botany in a laboratory with its fine equipment of microscopes, microtomes, ample laboratory space and an abundance of help on the part of laboratory instructors would find little in common with the early life of the late Dr. Beal, who began his botanical studies at a time when the idea of laboratory work by the student of botany was unheard of. The men of Dr. Beal's generation had to dig out their botany almost alone, and without most of the things now considered to be absolute necessities. The early scientific training and inspirations of his life are told most sympathetically in a little volume entitled "An American Pioneer in Science" and published privately by the authors, Ray Stannard Baker and Jessie Beal Baker, the latter the daughter of Dr. Beal.

Born in Adrian, Michigan, in 1833, Dr. Beal lived the life of a pioneer in the then frontier. Indians still lived in the vicinity and the woods abounded in wild animals. Schools were few and newspapers and books exceedingly rare. Yet the young pioneer gained what training was possible in the schools and academies of his vicinity and entered the University of Michigan, graduating with the class of 1859, all but one or two of whose members he was destined to outlive. He became a teacher in the Friends' Academy at Union Springs, New York. In the early sixties he entered Harvard, studying under Dr. Asa Gray, Dr. Charles W. Eliot and Louis Agassiz. The last named was the one whose impression was greatest, for he introduced Dr. Beal to the laboratory method of study, a method not then used at Harvard by either Eliot or Gray. After two years as professor of botany at the old Chicago University, Dr. Beal was called in 1870 to the Agricultural College of Michigan, serving as professor of botany, horticulture and forestry until gradually the departments of horticulture and, later, forestry were established, thus leaving him to his especially beloved botany. Following the inspiration gained from Agassiz, it was not many years until Dr. Beal introduced the laboratory method of instruction for botany, at a time when this was a startling innovation.

Besides his investigations and teaching work in botany, the subject of forestry received great attention. Dr. Beal was one of the first to preach conservation of forests, although that word was not then used. He lived to see the day when his predictions came true and many of the methods suggested by him were brought into practice. He was always more of a stu-

dent of the plant as a living object than as a subject for minute dissection, and therefore tried to interest his students in that aspect of botany, although recognizing the need for the other and giving instruction in it. Always the practical sides of a problem seemed to interest Dr. Beal. He felt that botany should be truly a handmaid to agriculture. Thus he carried on studies on weeds, the viability of seeds, etc. Yet a scientific discovery, if fundamental, was always able to arouse his enthusiasm, even if its practical aspects were not in the least discernible.

To the end of his long life the botany of the great out-of-doors was Dr. Beal's great delight. Even in his last months, when unable to walk on account of illness, he would have his chair wheeled out-of-doors and would call attention to various things of botanical interest.

Dr. Beal came of Quaker stock and preserved to the end the sterling honesty of action and speech instilled in him by his parents. Laziness he could not abide. He sought no vacations and never could bring himself to "loaf." Thus it was possible for him with no assistance in the greater part of his teaching career to train so many men who have carried forward the torch laid down by him at his death on May 12, 1924. His work lives after him in the many botanists and other scientists for whom he was the inspiration.

Ernst A. Bessey
Michigan Agricultural College

SCIENTIFIC EVENTS

THE CENTENARY OF HUXLEY

The centenary of the birth of Huxley was celebrated on May 4 by the Imperial College of Science and Technology with a lecture by Professor E. B. Poulton, an exhibition in the department of zoology, and a reception given by Lord and Lady Buckmaster. Lord Buckmaster is chairman of the governing body of the college. Mr. Herbert Wright presided and the vote of thanks to the lecturer was moved by Sir Charles Sherrington.

According to the report in the London *Times,* the lecturer began his address with a message from Sir Ray Lankester, the life-long friend of Huxley. He then discussed the early days of Huxley, and described some of the disappointments that he faced and overcame and some of the obstacles that impeded him when first he began to seek work of a definitely scientific character. The heights that Huxley reached, said Professor Poulton, were attained only by dauntless effort and determination.

The lecturer, continuing, referred to Huxley's keen sense of humor, and described how in admonishing an acquaintance he said: "You do not suffer fools gladly, you gladly make fools suffer." In declining an invitation to a spiritualistic gathering he said that it might all be true, for anything that he knew to the contrary, but he could not get up any interest in the subject, and disembodied gossip had no more interest for him than any other form of gossip. In discussing the controversial side of Huxley's career, Professor Poulton said that in disputes there was never any bitterness or estrangement; difference was never allowed to spread beyond the issue. Though Huxley became so effective a speaker, it was only the result of determination and practice. Before delivering his first lecture he said: "I can now quite understand how it feels to be going to be hanged." The clear and beautiful style of his writing was developed in the same way, and very often he would write an essay half a dozen times before he was satisfied with it. To Huxley Tennyson was the first poet since Lucretius who had understood the drift of science.

Much had been written in the press lately, the lecturer continued, about the need for books on economic subjects, but so far as he knew no reference had been made to Huxley's essays on that subject. Much misery would have been spared to the world if the advice he gave had been followed; he wanted to be remembered as a man who loved the people.

The best of Huxley's work, Professor Poulton said, was in his lectures to working men. They were greatly touched by what he did for them, and loved him for it. The great thing in his career was his defense of Darwin, leading on to the wider subject of his defense of freedom of thought. The lecturer discussed the weight of the traditional beliefs that lay in the path of the development of scientific inquiry at the time when Huxley was at the height of his career. No doubt his hard fight for a principle gave pain to many, but he never intentionally gave pain nor flippantly attacked the beliefs of others, and the privilege of the present freedom that we enjoy to pursue scientific investigations is due more to Huxley than to anybody else.

The chairman, in his speech, said that it was hoped that it might be possible to raise a permanent memorial to Huxley. The exhibition included rare books and a selection of Huxley's drawings in the Huxley Library, and a number of scientific exhibits elsewhere. There were exhibits and demonstrations by the various departments of the Imperial College of Science and Technology in the evening.

THE REORGANIZATION OF THE DEPARTMENT OF THE INTERIOR

At the closing session of the administrative council of the American Engineering Council in Philadelphia on May 10, support was pledged to the reorganization

of the Department of the Interior by the federal government.

The reorganization would bring about a saving of many millions of dollars, according to the report of the Committee on Government Reorganization, as recorded in the New York *Times*. President Coolidge urged passage at the last session of the Congress of the Mapes bill, which would have provided for two divisions in the Interior Department—one for Public Works and the other for Public Domain. The engineers voted to have a similar bill introduced in the next session of Congress carrying provisions for further reorganization.

All public construction work would be under the Division of Public Works and the control of all public land under the Division of Public Domain.

Under the Mapes bill, offices which spent a total of $107,148,584 in 1924 would be transferred to the Division of Public Works in the Department of the Interior. The estimated expenditures of these offices in 1925 are $118,617,706 and for 1926, $110,955,646. The engineers urged that in addition to these offices, all rivers and harbors work be done under the direction of the Department of the Interior, as well as several other works of less importance. The rivers and harbors work for 1924 cost $72,617,006 and the estimated expenditures for 1925 and 1926 are $75,204,856 and $61,987,448.

The report outlining the plans for the changes in the department was introduced by Gardner H. Williams, of Ann Arbor, Mich., chairman of the Committee on Government Reorganization.

Upon suggestion of William McClellan, formerly dean of the Wharton School of the University of Pennsylvania and recently appointed a member of the Muscle Shoals Commission by President Coolidge, the report was approved, with a statement inserted that army engineers could be used for rivers and harbors work only upon the request of the Secretary of the Interior. That was done to avoid the possibility of use of engineers from the army who were not as capable as civil engineers.

A resolution was passed urging that President Coolidge be asked to transfer the functions of the executive secretary of the Federal Water-Power Commission to the director of the Geological Survey. The resolution includes the following statement:

> The federal government is lagging behind the states in the development of water power. The nation's water power should be developed, and we suggest that a bill be introduced in congress providing adequate funds for the water-resources branch of the Geological Survey so that it can make steam gauges in a nation-wide, orderly way.

THE DOUGLAS SMITH FOUNDATION FOR MEDICAL RESEARCH

Establishment of the Douglas Smith Foundation for Medical Research, which is to make available to the University of Chicago the income from approximately $1,000,000 as endowment of research in the School of Medicine, was announced on May 20. Securities now valued at $800,000 have already been placed in the hands of officials of the university. The donor, Douglas Smith, a well-known Chicago business man, intends to turn over the remainder of the gift during 1925.

This contribution comes a short time after the breaking of ground for the School of Medicine, which is to be situated between Ellis and Drexel avenues and 58th and 59th streets. On this tract buildings costing more than $4,500,000, for the Albert Merritt Billings Memorial Hospital, the Epstein Dispensary and the departments of surgery, medicine, pathology, physiology and physiological chemistry, are to be erected. The university will then have on the midway an extensive group of buildings for medical instruction and research, in addition to those constituting the Rush Medical College group on the west side. The Douglas Smith Foundation is constituted specifically for payment of salaries of those conducting medical research and for the expenses of this work.

"Mr. Smith's notable contribution," said Harold H. Swift, president of the university board of trustees, "will be applied to the immediate inauguration of research in the School of Medicine. The university is grateful for this gift, which will provide stimulus to our $17,500,000 program for development of other departments of the university."

> The securities which I am handing you are for the establishment of a fund to be held in perpetuity by the University of Chicago as an endowment of its school or schools of medical science for the investigation of the causes, nature, prevention and treatment of disease. Only the net income of the fund is to be used. It is to be expended exclusively in payment of the research stipends or salaries of the members of the staff or fellows of the University of Chicago engaged in medical research, and of expenses directly incident to such research.
>
> I would have preferred that my name be not attached to this gift, but at your request I have agreed that the fund may be known as the Douglas Smith Foundation for Medical Research.

THE SECTION OF SOCIAL AND ECONOMIC SCIENCES OF THE AMERICAN ASSOCIATION

The Section of Social and Economic Sciences (K), of the American Association for the Advancement of

Science, plans an exceptional program on "Research methods and results" at the Kansas City meeting, to be held during the week beginning December 29.

The preliminary program of the section is given below. It emphasizes a wide range of discussions, which should prove of great practical value to all concerned:

Tuesday Morning Session, December 29, 10:00 A. M.

1. (Subject to be announced.) Address of the retiring vice-president for Section K, Dr. Thomas S. Baker, President of the Carnegie Institute, Pittsburgh, Pa.
2. Research in forestry taxation: address by vice-president for Section K, Professor Fred R. Fairchild, Yale University.
3. Research—The prime mover of industry: Mr. Maurice A. Holland, National Research Council, New York City.
4. The frontiers of industry: Mr. E. P. Stevenson, Arthur D. Little, Inc., Cambridge, Mass.

Tuesday Afternoon Session, December 29, 2:00 P. M.

5. Science, charlatanry and nutrition: Dr. H. E. Barnard, American Institute of Baking, Chicago.
6. Scientific nutrition and modern foods—facts and fancies: Dr. C. Robert Moulton, Institute of American Meat Packers, Chicago.
7. The future of agricultural research: Mr. E. W. Ball, Department of Agriculture, Washington, D. C.

Wednesday Morning Session, December 30, 10:00 A. M.

8. Cooperation between industry and university: Dr. George D. McLaughlin, Tanners' Council Laboratory, University of Cincinnati.
9. Science in an old industry—lime manufacture: Mr. G. J. Fink, National Lime Association, Washington, D. C.
10. (Subject to be announced.) Dr. Lewis H. Haney, Bureau of Business Research, New York University.

Wednesday Afternoon Session, December 30, 2:00 P. M.

11. Scientific research as applied to concrete construction: Mr. Duff A. Abrams, Structural Materials Research Laboratory, Lewis Institute, Chicago.
12. The administration of research under the industrial fellowship system: Dr. E. R. Weidlein, Mellon Institute, University of Pittsburgh.
13. Air transportation: Lieutenant J. Parker Van Zandt, Commercial Aviation Department, War Department, Washington, D. C.

Thursday Morning Session, December 31, 10:00 A. M.

14. Research and the incandescent lamp industry: Mr. W. E. Forsythe, National Lamp Works, Nela Park, O.
15. The economic basis of medical charges: Dr. Michael M. Davis, Jr., United Hospital Fund of New York.
16. Cancer research: Dr. F. L. Hoffman, Babson Institute and Prudential Insurance Company.

Thursday Afternoon Session, December 31, 2:00 P. M.

17. Résumé of research work of underwriters' laboratories: Mr. A. H. Nuckolls, Underwriters' Laboratories, Chicago.
18. (Subject to be announced.) Mr. F. O. Clements, General Motors Research Corporation, Dayton, O.
19. (Subject to be announced.) Mr. A. L. Viles, Rubber Association of America, New York City.
20. (Subject to be announced.) Representative, Research Division, Standard Oil Company, Elizabeth, N. J.

FREDERICK L. HOFFMAN,
Secretary of Section K

A PROPOSAL FOR SUMMER SESSIONS OF THE AMERICAN ASSOCIATION AT ITHACA IN 1926

AT the recent spring meeting of the executive committee of the council of the American Association it was voted that the committee looks with general approval upon a proposal to hold summer sessions of the association in connection with the next International Congress of Plant Sciences, which is being planned to be held at Ithaca from August 16 to 23, 1926. Dr. B. M. Duggar, chairman of the organizing committee for the congress, has invited the association to arrange for sessions in other branches of science to occur at the same time and place, stating that the facilities and accommodations will be ample for all sections of the association. The action of the executive committee, as noted above, is tentative only, and the committee will be glad to receive suggestions in this connection, pending a definite decision that is to be made later.

It is not infrequently suggested that eastern summer meetings of the American Association would be profitable to the members and the affiliated societies and useful in the advancement of science. Ithaca is an excellent place for a summer meeting. A large number of prominent students of the plant sciences in other countries will be present at the congress and the attendance of American botanical workers will be very large. Whether the American Association should plan a general meeting in connection with the congress, or sessions of certain sections only, and whether affiliated societies may desire to hold meetings in that connection, are questions regarding which the permanent secretary will be glad to receive information and suggestions. If an association meeting is to be planned the organization of the association will be available for all general arrangements for all the sections, including the affiliated and otherwise associated organizations. We are assured of the hearty cooperation

of the committee in charge of plans for the International Congress.

BURTON E. LIVINGSTON,
Permanent Secretary

SCIENTIFIC NOTES AND NEWS

THE Franklin Institute in Philadelphia on May 20 conferred Franklin medals and certificates of honorary membership on Dr. P. Zeeman, professor of physics in the University of Amsterdam, and on Dr. Elihu Thomson, of the General Electric Company, Lynn, Mass.

AT a meeting of the Association of American Physicians held on May 6 at Washington, the Kober lectureship was presented to Professor John J. Abel, of the Johns Hopkins University Medical School, and the Kober Association Medal to Dr. Hideyo Noguchi, of the Rockefeller Institute for Medical Research.

DR. HOWARD MCCLENAHAN, professor of physics, Princeton University, and for the last thirteen years dean of the college, has been appointed secretary of Franklin Institute.

DR. WILLIAM M. MANN, formerly entomologist in the Department of Agriculture, will succeed Dr. Alexander Wetmore as superintendent of the National Zoological Park. Dr. Wetmore was recently appointed assistant secretary of the Smithsonian Institution.

GEORGE F. WHITE has resigned his position as professor of organic chemistry at Clark University to accept a position as director of the scientific department of Bauer and Black, manufacturers of surgical dressings and allied products, at Chicago, Ill.

DR. EDWARD FRANKLAND ARMSTRONG, who has for some years been technical director in charge of Joseph Crosfield and Sons' Soapworks at Warrington, has been appointed managing director of the British Dyestuffs Corporation. Dr. Armstrong is the son of Dr. H. E. Armstrong, emeritus professor of chemistry at the City and Guilds College, South Kensington.

IN honor of Dr. Dean Lewis, of Chicago, professor-elect of the department of surgery of the Johns Hopkins University, the physicians and surgeons of western Illinois tendered him a banquet on May 5.

THE Remington honor medal of the New York branch of the American Pharmaceutical Association has been awarded to Dr. Henry M. Whelpley, dean of the St. Louis College of Pharmacy.

DR. MARTIN H. FISCHER, professor of physiology in the University of Cincinnati, has been elected a corresponding member of the Czecho-Slovakian Botanical Society for "services rendered to botanical science."

OFFICERS for 1925–26 have been nominated as follows by the American Society of Mechanical Engineers: *President,* William L. Abbott, chief operating engineer, Commonwealth Edison Co., Chicago, Ill.; *Vice-presidents,* Alex G. Christie, professor of mechanical engineering at the Johns Hopkins University; William T. Magruder, professor of mechanical engineering, Ohio State University; Roy V. Wright, managing editor of the *Railway Age; Managers,* Robert L. Daugherty, professor of mechanical and hydraulic engineering at the California Institute of Technology; William Elmer, superintendent of the middle division, Pennsylvania Railroad System; Charles E. Gorton, chairman of the American Uniform Boiler Law Society; *Treasurer,* Erik Oberg, editor of *Machinery.*

AT the Niagara Falls Meeting of the American Electrochemical Society the following officers for 1925 were elected: *President,* Frederick M. Becket; *Vice-presidents,* Wm. Blum, F. C. Frary and E. F. Cone; *Managers,* H. W. Gillett, F. N. Speller and J. Watson Bain; *Treasurer,* Acheson Smith; and *Secretary,* Colin G. Fink.

AT a meeting of the International Union of Geodesy and Geophysics of the National Committee of Canada, held in Ottawa, January 30, 1925, the following officers were elected: *President,* Noel J. Ogilvie, director of the Geodetic Survey of Canada, Ottawa; *Secretary,* Ernest A. Hodgson, seismologist of the Dominion Observatory, Ottawa.

THE following officers were elected at the annual business meeting of the Iowa chapter of the Sigma Xi: *President,* Professor B. T. Baldwin; *Vice-president,* Professor P. A. Bond; *Treasurer,* Professor E. W. Chittenden; *Secretary,* Professor C. J. Lapp. The chapter was organized in June, 1900.

DR. GEORGE W. CORNER, professor of anatomy at the University of Rochester, addressed the first open meeting of the Sigma Xi Club of the University of Buffalo, on May 21. The subject of the lecture was "Problems of the human reproductive cycle." The Sigma Xi Club was organized at the University of Buffalo early in 1924. Its membership includes fifteen alumni members of the society on the university faculty and alumni members in Buffalo and environs. The officers for the first year, during which a constitution was formulated and adopted and several stimulating meetings held, were: *President,* Dr. Wayne J. Atwell; *Secretary-treasurer,* Dr. Fred R. Griffith, Jr. Officers for the coming year, recently elected, are: *President,* Dr. Frank A. Hartman; *Secretary,* Dr. Fred R. Griffith, Jr.; *Treasurer,* Professor Albert

R. Shadle; additional members of the executive committee, Drs. Edward A. Moore and Wayne J. Atwell.

DR. MARY ELIZABETH HANKS has been elected president of the Chicago Council of Medical Women. Dr. Florence Johnston, assistant editor of the *Journal* of the American Medical Association, has been appointed secretary.

DR. M. M. LEIGHTON, chief of the Illinois State Geological Survey, was recently elected chairman of the St. Louis Section of the American Institute of Mining and Metallurgical Engineers.

YING LAM PUN, Ph.D. (Ohio State), formerly instructor in the department of chemical engineering, has been traveling around the world for the last nine months on his way home to China. Dr. Pun has made a series of addresses in Great Britain, Holland, Germany, France, South Africa and India before Chinese Chambers of Commerce on the industrial conditions and future of China. Dr. Pun is at present in Burma.

PAUL JACKSON has joined the research department of the Bakelite Corporation.

E. WADE ADAMS has resigned his position as assistant professor of chemistry at the Kansas State Teachers' College of Pittsburg to accept a position as research chemist in the laboratory of the Standard Oil Company, Whiting, Ind.

DR. PHILIP B. HAWK is removing his Food Research Laboratory from Duxbury, Mass., to New York City in June.

DR. WALTER H. SNELL, head of the department of botany in Brown University, will resume his work as assistant forest pathologist for the New York Conservation Commission during the coming summer. He will continue various studies upon the white pine blister rust for the commission.

DR. BRADLEY M. DAVIS will spend the summer in England with headquarters at the John Innes Horticultural Institution, Merton.

DR. T. A. JAGGAR, director of the Hawaiian Volcano Observatory of the U. S. Geological Survey, is making a visit to Washington.

DR. CHARLES E. WEAVER, who has spent three years in geologic work in Argentina, will in September resume his position as professor of paleontology in the University of Washington, Seattle.

DR. M. I. PUPIN, professor of electro-mechanics at Columbia University and president of the American Association for the Advancement of Science, will give the principal address at the commencement exercises of Swarthmore College on June 11.

PROFESSOR WILDER D. BANCROFT, of Cornell University, lectured on May 12 before the Swarthmore Chapter of the Society of Sigma Xi on "The ramifications of a research problem."

PROFESSOR CHARLES A. KOFOID, of the University of California, delivered a lecture on "Hookworm and amoebiasis as a public health problem," at the Rice Institute on May 8.

DR. E. E. SLOSSON, of Science Service, will speak on June 1 at the annual meeting and dinner of the Alumni Association of the Graduate Schools of Columbia University, on "Science and superstition."

DR. H. FREUNDLICH will address on May 28 a joint meeting of the Washington Academy of Sciences, the Chemical Society of Washington and the Philosophical Society of Washington, on "The state of aggregation and form of colloid particles."

PROFESSOR C. K. LEITH, of the department of geology of the University of Wisconsin, will lead a round-table conference on "International aspects of mineral resources" at the fifth session of the Institute of Politics, at Williamstown, Mass., for four weeks beginning on July 23.

PROFESSOR HENRY H. GODDARD, of the department of psychology of the Ohio State University, sailed for Honolulu on May 13, to deliver a series of lectures under the auspices of the University of Hawaii.

AMONG the five busts unveiled in the Hall of Fame of New York University on May 21 is one of Asa Gray, the botanist. The bust is the work of Chester Beach, and was presented to New York University by the Gray Herbarium of Harvard University and friends and relatives of Mr. Gray. Miss Katherine P. Loring made the presentation and Miss Alice A. Gray unveiled the statue. Dr. Charles W. Eliot, president-emeritus of Harvard University, spoke through the phonofilm and Professor Benjamin L. Robinson, professor of systematic botany at Harvard University, made the address.

JOHN EDWARD MCGRATH, formerly of the U. S. Coast and Geodetic Survey, the discoverer of Mount Logan, died on May 7, at the age of sixty-nine years.

THE REVEREND FATHER ALOYSIUS LAURENCE CORTIE, S. J., astronomer and director of the Stonyhurst College Observatory, England, died on May 16, aged sixty-six years.

OTAKAR BARKUS, a graduate in chemistry of the University of Prague, Czecho-Slovakia, recently associated with the University of Nebraska, died at Saranac Lake, N. Y., on May 8, at the age of twenty-seven years. He had published several articles in *The American Journal of Physiology.*

THE following cable, dated May 21, has been received by President Vincent, of the Rockefeller Foundation, from the secretary general of the League of Nations, Geneva: "Deeply regret inform you Drs. Samuel Darling and Norman Lothian met with fatal automobile accident while traveling as members League of Nation's Malaria Commission near Beirut yesterday." Dr. Darling, who for the past ten years has been a member of the staff of the International Health Board of the Rockefeller Foundation, has made important contributions to scientific knowledge of malaria, relapsing fever, dysentery and parasitic diseases, particularly hookworm disease, filariasis and trypanosomiasis. He was born in Harrison, N. J., in 1872, and received his degree in medicine at the College of Physicians and Surgeons, Baltimore. From 1906 to 1915 he held the post of chief of laboratories of the Isthmian Canal Commission, Panama Canal Zone.

THE late Sir T. Clifford Allbutt, Regius professor of physics in the University of Cambridge, who died in February last aged 88 years, has bequeathed to the Fitzwilliam Museum of Cambridge his portrait by Sir William Orpen, R.A., and on the death of his wife a quantity of antique furniture and drawings and paintings by noted artists, including Romney, Landseer, Rossetti, Watts and Turner.

THE second general assembly of the International Astronomical Union will be held at Cambridge, England, from July 14 to 22.

THE third annual meeting of the Virginia Academy of Science was held in Richmond on May 1 and 2, together with the Virginia section of the American Chemical Society. At the business session the academy voted to become affiliated with the American Association for the Advancement of Science on the terms set forth in their recent memorandum on the relations between affiliated academies and the association, as has already been recorded in SCIENCE. Dr. Robert E. Loving, of the University of Richmond, was elected president for the coming year.

THE third annual banquet of the Sigma Xi club of the Kansas State Agricultural college, with several visiting members of the Sigma Xi chapter at the University of Kansas in attendance, was held on April 24. Sixty-two members, including fifteen from the University of Kansas, attended. Dr. R. K. Nabours, president of the local club, acted at toastmaster. Dr. Raymond C. Moore, head of the department of geology of the University of Kansas, and state geologist, spoke on "Contributions of geology to the progress of science." Dr. Nobel P. Sherwood, head of the department of bacteriology, spoke on "The service of medicine in the progress of man." Professor J. W. McColloch, of the department of entomology at the Kansas State Agricultural College, discussed "The advancement of science with the study of insects," and E. C. Miller, of the department of botany, "The study of plants as an aid in scientific progress."

UNIVERSITY AND EDUCATIONAL NOTES

THE sum of $200,000 has been given to the University of Chicago by Mr. Charles H. Swift. This gift has for its purpose the institution and maintenance of a "distinguished service professorship." It is the first professorship endowment at Chicago yielding an income of $10,000. Other endowments are expected to follow to supply financial rewards for distinguished service. Present members of the faculty and outsiders will be eligible. Mr. Max Epstein has contributed $10,000 for "scientific work in medicine or one of the allied sciences." The university has also received $53,000 from Mr. Morton D. Hull and an anonymous gift of $50,000.

DR. GLENN FRANK, editor of *The Century Magazine*, has been elected president of the University of Wisconsin.

PROFESSOR GREGORY P. BAXTER, teacher of chemistry at Harvard since 1897, has been named Theodore William Richards professor of chemistry. This professorship was recently established at Harvard by Thomas W. Lamont, and Professor Baxter, a graduate of Harvard College in 1896, is the first incumbent. A second new chair in chemistry is also announced, the Sheldon Emery professorship of organic chemistry. Professor Arthur B. Lamb, director of the chemical laboratory, is named as the first incumbent of the new chair. Dr. William John Crozier, professor of zoology at Rutgers College, has been appointed associate professor of general physiology.

DR. J. E. WODSEDALEK, head of the department of zoology and director of pre-medical and graduate studies at the University of Idaho, has been made dean of the graduate school.

DR. EDWARD L. TROXELL, of Yale University, has been appointed professor of geology and dean at Trinity College.

DR. SEWALL WRIGHT, senior husbandman in charge of animal genetics in the bureau of animal industry, U. S. Department of Agriculture, has been appointed associate professor of zoology in the University of Chicago. Dr. Wright will have charge of the subject of genetics in the department of zoology dating from January 1, 1926.

The following promotions have been made in the department of physics of the University of California: From assistant to associate professor, Frederick S. Brackett and Leonard B. Loeb; from instructor to assistant professor, J. J. Hopfield and V. F. Lenzen.

Dr. Wolfgang Koehler, professor of psychology in the University of Berlin, as has already been stated in Science, has been appointed visiting professor of psychology in Harvard University for the first semester of the year 1925–26. He, however, remains during this period visiting professor in Clark University, where he has been since February of this year.

Dr. Harold A. Wilson, F.R.S., professor of natural philosophy in the University of Glasgow, has accepted reappointment to the professorship of physics which he held at the Rice Institute from 1912 to 1924 inclusive.

DISCUSSION AND CORRESPONDENCE

PHOTOGRAPHING THE SHADOW BANDS

Previous to the recent solar eclipse great interest was displayed in the problem of photographing the shadow bands. The conditions were unusually favorable, and very many persons must have made attempts to photograph the bands. It was therefore to be expected that many such photographs would be taken and that some of them would find their way into the newspapers and magazines. However, up to the present moment I have neither seen such pictures nor seen in print any mention of their having been secured. It may therefore be of interest to know that a photograph of the shadow bands was secured by a photographer of this locality.

The negative is four by five inches in size and shows in the foreground five shadow bands on a plane snow surface. Unfortunately, the exposure was too short and the picture is therefore "thin." It could scarcely be reproduced for magazine or newspaper printing, but photographic copies are sufficiently clear to be of scientific interest. The only object in the picture serving to fix the size is a footprint in the snow. It is therefore difficult to estimate the size of the bands. Each shadow appears to be about eighteen inches long, three or four inches wide and separated from its neighbor by about ten or twelve inches. This agrees with the observations made by the writer at a point not much more than a mile from the photographer's station.

In all characteristics the photographs appear to represent wave phenomena. In length, width, relative position and shading, the shadows in the picture exactly imitate a water surface rippled by the wind. In fact, in looking at the picture one can not escape the feeling that the surface of the snow is thrown up in waves, so perfect is the illusion of wave form. This agrees well with the suggestion that the shadow bands are caused by the light shining through a rippling surface of contact between two layers of air of differing density. This is supported by the observation made by the writer that the bands were moving in the same direction as the lower air currents (northeastward) and at approximately the velocity of the air movements.

The gentleman who made the photograph is Mr. Glen Lowry, a professional photographer, of Stroudsburg, Pa. He kindly supplies the following photographic data:

Location, three miles north of Port Jervis, N. Y., on road leading to Huguenot. Graflex camera, Eastman super-speed film, F 4.5 aperture, 1/1000 second exposure, exposure made just one minute after close of totality. The exposure might well have been five to ten times longer.

W. L. Eikenberry

State Normal School
East Stroudsburg, Pa.

THE GERMINATION OF BARLEY UNDER LATE SPRING MALTING CONDITIONS IN INDIA

The malt houses of India are not equipped with the elaborate control apparatus found in many of our American plants. The summers are very hot and no malting is done in midsummer. To secure a longer malting season malt houses have been established in the hills at some elevation. I visited one of these at the time the last malt of the spring was on the floor. The temperature at this season is high and the air dry. Some peculiarities of germination under these conditions seem worthy of noting.

The barley is a very fine grade of grain with an unusual uniformity of development and soundness. In midwinter practically perfect germination is secured. The best malting conditions probably obtain in December. At this time the temperature of the malting floor is about 60° F. and the air sufficiently humid to grow the grain with no additional water after the soak. In June, however, when the last malting is done, the floor is actually hot to the touch. Daily sprinklings are given the grain. Yet at this time with high temperature (74° F.) the grain remains on the floor for twelve days or longer. Under fast malting conditions in the United States the plumules are often protruding in five or six days. The plumule of the high temperature malt of India has hardly started at the end of twelve days. The Royal Pilsen malt of Austria, which is commonly regarded as the world's best, is characterized by a growth of plumule two thirds the length of the grain in practically every kernel. The plumules of Ameri-

can malts are longer grown. In the June malt of India the plumule is less than one third the length of the kernel. It seems inconceivable that the normal changes of endosperm would take place with a subactive embryo, as the starch-converting enzymes are secreted by the epithelial layer of the scutellum. The conversion is, however, quite good. A comparison of the June and December malts is given below.

	June	December
Starch per cent.	43.07	39.69
Reducing sugars as invert per cent.	2.64	3.31
Reducing sugars as maltose per cent.	4.83	5.89
Sucrose per cent.	3.71	2.72
Diastatic capacity on Lintner's scale	51.10	56.90

The explanation of this behavior must rest in the fact that the optimum temperature for the germination of barley is fairly low and that its germination vigor decreases rapidly at temperatures higher than the optimum. The enzyme secretion must not be retarded to the same extent as growth. Maltsters in India believe that the local barleys do not germinate well until the winter season approaches and that the viability begins to wane by May. In June the percentage of germination is much reduced. Tests made in Washington from a sample of the barley which germinated weakly in India the previous June show its vitality to be unimpaired when grown at temperatures such as exist in India in December.

If saturated burlap were used to lower the temperature of the malting rooms and increase the humidity in India, it is probable that the June malt would behave more nearly like that of December.

H. V. HARLAN

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A FABLE

THE following fable was found in an old palimpsest of obscure origin, but probably derived from both English and French sources. A critical study suggests that the work of the original author has been supplemented by the copyists, especially in the addition of adjectives. I transcribe it, however, as it came to me. Since truth is eternal, the fable may even yet have a bearing on modern speculation.

The Genealogy of Theory

A Fable

Suggestion, an eager Boy, met a winsome Maid, Credulity by name, and begat Plausibility, an enchantress.

She mated with a chance acquaintance, Coincidence, and bore him Belief, a stalwart Youth who set out to conquer the World.

But across his shield was blazoned the bar sinister. Reason had not consecrated either union.

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AMANITA MUSCARIA IN MAINE

Amanita muscaria in the coastal woods of eastern Maine is frequently found with pitted upper surface and indented edges, the pits and indentations bearing tooth marks apparently of rodents. The common red squirrel has twice been seen by the writer, holding bits of this mushroom in his fore paws and eating them. A friend, a geologist, says that he has a number of times observed the red squirrel's habit of eating this mushroom. Are these observations of any interest to students of mushroom poisoning?

MAYNARD M. METCALF

NATIONAL RESEARCH COUNCIL

SCIENTIFIC BOOKS

A Text-book of General Botany. By WILLIAM H. BROWN. Ginn & Company, pp. xi + 484, 1925.

Laboratory Botany. By WILLIAM H. BROWN. Ginn & Company, pp. xiv + 168, 1925.

ON opening this most recent of the textbooks of botany one is surprised to find the author writing from a university in the tropics, the University of the Philippines. One's interest is at once aroused as to how the subject will be presented by one teaching in a tropical country, and whether a text so written is applicable to classes in temperate zone countries. We will let the book answer for itself.

There are two outstanding features in Professor Brown's text: first, its universality in the selection and presentation of subject-matter, and second, its excellent illustrations.

The first is the natural outgrowth of many unsuccessful attempts to adapt texts written by botanists in temperate zone countries for temperate zone students, for the use of students in tropical countries. The author states in his preface: "In this book an attempt has been made to treat botany from the standpoint of general principles rather than as illustrated by special plants used as types, and from a world point of view rather than from a local one." The author proceeds to carry out this purpose by discussing each topic in a general way; defining, describing and locating, whether it be a sieve tube or a starch grain, without mentioning what specific plants may be used to illustrate the point under discussion. This method gives the experienced instructor entire freedom to choose his sieve tubes from squash or sugar cane and his starch grains from potato or rice, hence meets the needs of the teacher in temperate and in tropical countries alike. The beginning instructor, on the other hand, will be aided by the complete labeling, including the name of plant used, of the many cuts used to illustrate the points discussed in the text. This feature will appeal to many botanists and is needed to counteract the seeming tendency to illustrate all botanical principles by the use of a few familiar plants.

The author emphasizes the similarity between botanical features in temperate zones and in the tropics and furthers his idea of the universal viewpoint in botany by his method of presenting such topics as leaf fall and annual rings connected with growth. He presents them as being the effects of adverse conditions rather than as due to a winter season. The necessity of stressing this method of presentation is easily seen when one remembers that even some recent textbooks of botany state specifically or leave the inference that all trees have annual rings of growth.

The illustrations, of which there are 518, are the most attractive feature of the book and are its most valuable contribution to the teaching of botany. Done directly under the author's supervision by assistants racially and temperamentally fitted for the most painstaking accuracy, they represent an enormous amount of patient work and study. And the result is worth the effort! The text is unique in the large number of original drawings. Of the 465 cuts (there are 53 half-tones) only 28 are redrawn wholly or in part from the works of others. The drawings certainly ought to be "an inspiration to the student and an incentive for him to make good ones himself." Considerably over half of the species used for illustrating various principles are of universal distribution, available in both temperate and tropical countries.

The plan of the book follows even more closely than recent texts the idea of the inseparability of structure and function. After a chapter on the plant and one on the cell, the leaf is discussed and, in the same chapter, such physiological topics as hydration, photosynthesis, respiration and transpiration. This is followed by a chapter on the stem, including responses, movement of materials and growth, and a chapter on the root, including absorption, growth and a discussion of soils. Each chapter ends with a discussion of specialized leaves, stems and roots, respectively. Chapters on the flower, heredity and evolution, and the fruit and seed follow; and under these headings the functions of pollination, digestion and germination are taken up. The divisions of plants, discussed under the headings Thallophyta, Bryophyta, Pteridophyta and Spermatophyta, cover only 128 pages, the greater part of the book being devoted to the structure and functioning of the higher green plants. The author believes that the greater importance of the higher plants in the students' environment justifies a greater amount of space being devoted to them. A final chapter on plant geography covers the various types of vegetation of the world as determined by environment, such as tropical rain forests, cold temperate deciduous forests, tundra, deserts, fresh-water vegetation and others. Several pages are devoted to succession and climax vegetation.

Controversial matter is avoided, but several of the newer phases of botany are considered, such as colloids, hydration and the effect of light on growth. Certain points are discussed somewhat more fully than is usually the case in elementary texts; as movement of stomates, trichomes, phyllotaxy, arrangement of mechanical tissues, soils, Mendelism, plant breeding, evolution and the kinds of food stored in plants.

Care is taken to avoid using an undefined term, hence the first part of the text may seem cumbersome because of the definitions of terms given as the discussion proceeds. These terms are later however more fully explained in their proper place.

The laboratory botany follows the text closely and gives a series of 185 exercises, headed drawing, experiment, observation; or combinations of these depending on what is required in the exercise. The directions in the early exercises are very full, but as the student gains familiarity with the subject they are shortened. The author prefers that the student secure information not obtainable by observation of the specimen or the experiment from the manual rather than from the instructor. Likewise few questions are asked of the student, the author believing that "too many questions hinder rather than encourage independent thought and observation." The exercises, as is the case with the text, are written in a general way so as to be "applicable to average plants rather than to a particular species," thus furthering the author's emphasis on general principles of botany. The two books are intended to cover a year's work with beginning classes in botany but have been used for semester classes by omitting many of the laboratory exercises and portions of the text. Even in a year's course some of the material may be omitted at the discretion of the instructor. This applies particularly to the lower forms of plants.

Representing as it does the views of another botanist as to how the subject should be taught, the book is likely to be of interest and value to those engaged in teaching.

The publishers deserve credit for the excellent work done in reproducing the line drawings and the halftones.

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THE POSSIBLE ORIGIN OF THE ANGIOSPERMS

DR. H. HAMSHAW THOMAS, lecturer in botany of Downing College, Cambridge, has just published an important paper under the caption: "The Caytoniales, a new group of angiospermous plants from the Jurassic rocks of Yorkshire."[1] The origin of the

[1] Phil. Trans. Royal Soc. London, Series B, vol. 213, pp. 299–363, pls. 11–15, Feb. 21, 1925.

angiosperms has long been one of the "Dark Ages" in the evolutionary history of plants. This group, now the dominant plant type, seems to spring so suddenly into existence in the Middle Cretaceous, not only in one place but all over the world, with such a multiplicity of recognizable modern forms as forcibly to suggest that it must have had a long anterior period of development. But concerning this early history we are still pretty much in the dark, though an occasional ray of light stimulates further study and the hope that sooner or later we shall be able to work out a fairly complete account.

In 1904 Professor A. C. Seward described and figured a little leaf from the Stonesfield slate (Middle Jurassic) of East Yorkshire that has every appearance of being a dicotyledon. He wrote as follows: "Had the specimen been found in rocks known to contain remains of angiosperms, there would be no hesitation in identifying it as the leaf of a dicotyledon," but with characteristic caution he called it Phyllites sp., which is a convenient catch-all for any plant of doubtful systematic position. In 1912 Dr. Marie Stopes described petrified fragments of angiosperm wood of several types from the Lower Greensand beds of England. Remains supposed to be those of angiosperms have been reported from supposed Jurassic of Portugal, Australia and South America, but they are not wholly convincing.

The present study of Dr. Thomas is another possible link in the chain and is most welcome. The material on which it is based comes from the celebrated locality in Yorkshire, which has been an unfailing source of supply for Jurassic plants for nearly a hundred years. It is Middle Jurassic in age. The specimens described fall, according to the author, into four groups —two groups of carpels, fruits and seeds, one group of microsporophylls with anthers, and finally the leaves associated with these remains. They are placed in four genera, each with a single species, and fall within a single group, for which the name Caytoniales is proposed.

Perhaps the most important form is Gristhorpia, based on megasporophylls bearing subopposite, pediceled carpels and fruits, inclosing numerous ovules or seeds. The ovules are distributed irregularly over a large part of the inner side of the carpel wall. Much of the structure of the seed has been made out, including the micropyle and the several seed coats, but unfortunately the embryo could not be found. Evidently allied to this is Caytonia, which had the carpels similarly arranged in two opposite rows, but the ovules are disposed in two rows on the dorsal wall of the ovary. Many of the details of structure have been made out for these seeds also, though the embryo is missing. The male flowers, called Antholithus, consist of clusters of four-winged stamens, with peculiar-shaped pollen grains much as in Pinus, that is, there is a central portion with two lateral sacs or wings.

Great interest attaches to the leaves, long known as *Sagenopteris phillipsi*, that were found in close association with these fruits and seeds. The systematic position of *Sagenopteris* has been much discussed, and from their more or less close association with sporocarps of plants resembling those of Marsilia it has quite generally been referred to the Hydropterideae. Great numbers of these *Sagenopteris* leaves were found with the fruits and seeds and are apparently the only foliar organs that can with reasonableness be presumed to represent their foliage. As the author points out, with fruits and seeds as numerously represented as these are, it is natural to suppose that leaves would also be present. These leaves are described and discussed at length and numerous comparisons made with certain supposed early forms of dicotyledonous foliage, such as Rogersia, Proteaephyllum and Ficophyllum, from the lower Potomac of Virginia. In concluding the discussion of the leaves the author says: "We may take the view that, while it can not be regarded as definitely proved, there is a strong probability that the leaves of the Caytoniales were of the type known as *Sagenopteris*, and that it is more probable that *Sagenopteris* belonged to the Caytoniales than that it was the leaf of one of the Hydropterideae."

Dr. Thomas sums up his conclusions as to the possible affinities and interrelationships of these interesting plants as follows:

> A comparison of the Caytoniales with other seed plants seems to indicate that affinities may be traced with the Pteridosperms, Bennettitales, Gnetales and modern Angiosperms.
>
> Resemblances with the Pteridosperms may be found in the general form of the mega- and micro-sporophylls, while some of the details of seed structure in *Caytonia* are comparable with those seen in the Conostoma group.
>
> The comparison with the Bennettitales and the Gnetales is confined mainly to the structure of the integuments of the seed. The form and cutinisation of the micropyle in the seeds of *Caytonia* is more like that seen in *Gnetum* than in any other seed.
>
> The Caytoniales possess two of the features most characteristic of the modern flowering plants, *viz.*, the closed carpel with a stigma, and the anther with four longitudinal lobes. On this account it seems permissible to group them with the modern Angiospermae, though they do not seem to resemble any modern family. It is possible that they belong to a line of evolution which was quite distinct from that which gave rise to the modern Dicotyledons and Monocotyledons, and represent a parallel series of forms now completely extinct.
>
> The Caytoniales seem to occupy a position between the

Paleozoic Pteridosperms and the recent Angiosperms, and thus they suggest a possible solution for one of the great outstanding problems of evolution.

F. H. KNOWLTON

U. S. GEOLOGICAL SURVEY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A MODEL OF MUSCULAR CONTRACTION[1]

IT is rather difficult to imagine the muscle-fiber shortening as a result of swelling and increase of internal tension. The following model, constructed on

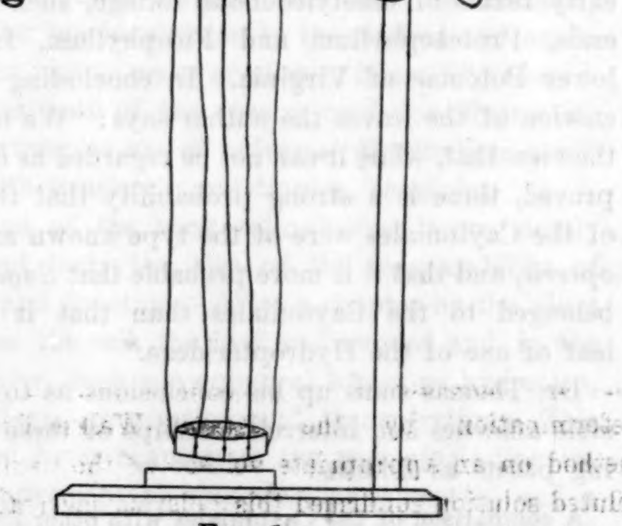

FIG. 1

a suggestion of L. Wacker,[2] 1917, is useful to illustrate the possibility of such shortening to students. The muscle fiber is represented by a thin rubber condom. A cork disk, 3 cm in diameter and 1 cm high, is placed in the bottom of the condom, and a similar but perforated cork in the opening. This bears a glass tube for blowing into the condom. Outside the condom and over the corks are two rings of brass, between which threads are stretched, 1 cm apart. On blowing into the tube, the condom swells; but as the strings prevent it from lengthening, the sides bulge and so shorten the condom. The two positions are shown in the figures.

The same phenomenon may be shown with dead small intestine from a rabbit or dog. A segment of

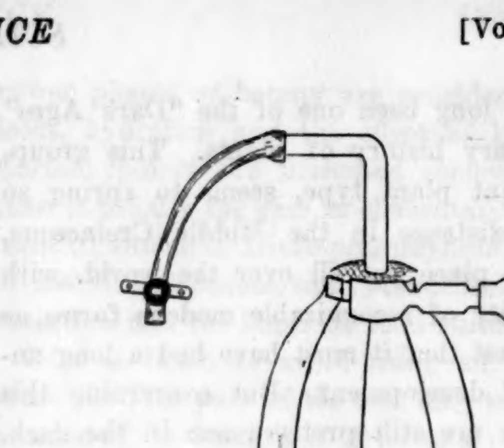

FIG. 2

intestine, about 10 cm. long, should be kept in normal saline solution for a day or two, at room temperature, to insure absence of vital tone changes. It is then arranged as in the Trendelenburg[3] peristalsis method. When the reservoir is raised, a centimeter at a time, the tracing lever shows progressive shortening, which disappears progressively when the reservoir is gradually lowered.

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1 From the Department of Pharmacology of the Medical School of Western Reserve University, Cleveland, Ohio.

2 Wacker, L.: Arch. ges. Physiol., 1917, clxviii, 158.

3 Trendelenburg, Paul: Arch. f. exp. Path. Pharm., 1917, lxxxi, 55.

SPECIAL ARTICLES

THE PRESENCE OF TREHALOSE IN YEAST

IN connection with studies on "Bios," an alcohol extract of Fleischmann's yeast was permitted to stand undisturbed for several months when a cluster of well-formed crystals was found clinging to the sides of the flask.

Preliminary tests indicated that it was a non-reducing, hexose containing di- or poly-saccharide. It was found to be exceedingly soluble in water and glacial acetic acid, either hot or cold, and somewhat less soluble in pyridine. It was insoluble in acetone. Unusual resistance to hydrolysis was shown by the fact that, after treatment with boiling glacial acetic acid, a Fehling's test was negative. Only when a solution of the crystals in N/2 HCl had been heated in a boiling water bath for one half hour was a positive Fehling's test obtained.

For more detailed investigation additional material was necessary. Securing these crystals a second

time did not prove a simple task. Finally, after several unsuccessful attempts with small quantities of yeast, forty pounds of compressed yeast were air-dried and then extracted in a large, continuous-extraction apparatus, first with ether for eighteen hours, followed by four portions of 90 to 95 per cent. alcohol for periods of eighteen to twenty hours each.

These combined alcohol extracts were stored in large glass bottles and seeded with small portions of the original material. After eight to ten days crystals began to form on the sides of the bottles. These were permitted to grow until there seemed to be no further increment in size. The alcohol was then decanted and the crystals dissolved in hot glacial acetic acid. After the solution had cooled ten to twelve volumes of acetone were added. The creamy, flocculent precipitate was filtered off and washed several times with acetone. A water solution of this precipitate was decolorized with charcoal, concentrated to a syrup and diluted with hot alcohol to make about 70 to 80 per cent. Care was taken at this stage to keep the solution hot and to add the alcohol slowly to prevent the reformation of a flocculent precipitate. Acetone was finally added until the solution just began to appear milky. It was then seeded with crystals and set under a bell jar to cool. This was to prevent any considerable absorption of moisture from the atmosphere. Within twenty-four hours large rock-candy-like crystals were found on the stirring rod and sides of the beaker.

The alcohol decanted from the crude crystals was evaporated in vacuo, the residue extracted with glacial acetic acid and further treated as described above. In this case the alcohol-acetone solution stood several weeks before the crystals began to form. The presence of impurities retards and may even prevent entirely the separation of this substance in crystalline form. When relatively pure it can be recrystallized from hot alcohol in a few hours.

After four or five recrystallizations from hot alcohol and acetone the substance was entirely colorless and odorless.

A melting point determination showed the characteristic behavior of trehalose, the crystals becoming fluid at 102.5° C., solidifying at 125° to 135° and melting again at 208° to 209°. Melting point determinations previously reported vary considerably. Mitscherlich[1] describes crystals of trehalose as losing water of crystallization at 130° C. and melting at 210° C. Later work by Lippmann[2] gives the melting point of the hydrated sugar as 103° C., loss of water of crystallization at 130° C. and a second melting point at 203° C.

Polariscopic readings were taken on a 20 per cent., a 10 per cent. and a 5 per cent. solution. The $[\alpha]_D^{20}$ values obtained from these observations were 184.6, 184.55 and 182.8, respectively. Correcting for the two molecules of water which trehalose contains, the $[\alpha]_D^{20}$ values for the anhydride were 204.02, 203.96 and 202.04. Various determinations quoted by other authors give the $[\alpha]_D^{20}$ value for the hydrated sugar as 167.4[3], 173.4[4] and 178.3[5]; for the anhydride as 197.3,[5] 198.6[6] and 201.5.[7] Our figures are higher than any quoted, suggesting a greater purity of the sugar.

Molecular weight determination by the freezing point method gave results of 354.6 and 358, considerably below 378, the molecular weight of the hydrated sugar. It is obvious that for substances of high molecular weight this method is not sufficiently delicate to obtain greater accuracy of results.

As has been stated before this substance is hydrolyzed with difficulty. To 20 cc of a 5 per cent. solution 2 cc of HCl, [sp. gr. 1.125,] were added and the mixture boiled under a reflux condenser for two and one half hours. The polariscope reading was then taken and again after an additional half-hour heating. Constant readings were obtained, and were such as would account for two molecules of glucose for each molecule of the original sugar. A glucose determination by the Munson-Walker-Bertrand method on an appropriate volume of the neutralized diluted solution confirmed this polariscopic reading.

A third portion of the neutralized solution was used for the osazone test. Only glucosazone was found. Distillation for furfural gave no phloroglucide in the distillate.

These observations all confirmed the original melting point determination, which identified the unknown crystalline substance with trehalose.

Trehalose is found with mannite in mushrooms. Bourquelot and Herissey[8] believe that *trehalose* and

[1] Mitscherlich, Erdman's Prak. Chemie, Vol. 73, 65 (1858).

[2] von Lippmann, E., *Berichte der Deutschen Chemischen Gesellschaft*, Vol. 45, 3431 (1912).

[3] Wiggers, H. A., *Annalen der Chemie u. Pharmazie*, Vol. I, 173 (1832).

[4] Berthelot, *Annales de Chim. et de Phys.* (3), 55, 372 (1859).

[5] Harang, P., *Journ. de Pharm. et de Chim.*, Vol. 23, 16 (1906).

[6] Müntz, M. A., *Annales de Chimie et de Phys.*, 5e serie, Vol. 8, 56, 1876.

[7] Bourquelot, Em., *Compt. Rend. de l'Acad. des Sc.*, Vol. 108, 568 (1889).

[8] Bourquelot, Em., et Herissey, H., *Compt. Rend. de l'Acad. des Sc.*, Vol. 139, 874 (1904).

trehalase have the same function in mushrooms as *sucrose* and *invertase* perform in chlorophyll-containing plants, in that they may be involved in the hydrolysis or synthesis of the higher carbohydrates.

In 1876 Müntz[6] looked for trehalose in brewer's yeast, thinking that since it was so generally present in higher fungi it should also be found in the lower fungi such as yeasts. His several attempts to separate it from the water and alcohol extracts of yeast were a failure. He concluded that either this sugar does not exist in yeast, or that the large amounts and the diversity of other soluble substances present therein make its separation from the solutions impossible.

The present discovery of trehalose in an alcohol extract of baker's yeast was due to the comparative freedom from impurities, the relatively high concentration of trehalose and the fact that the solution stood undisturbed for a long time. It was under similar conditions that the same sugar was first found by Wiggers[3] in a water solution of rye ergot.

The alcohol extract of yeast from which trehalose was separated was slightly acid. It is a question whether it exists in the yeast cell as such or is a hydrolysis product formed during the long extraction process.

A similar extract of yeast added in small amounts to a medium in which yeast is growing increases to a marked extent the invertase content of the yeast grown.[6] It is possible that trehalose is responsible for such an effect on enzyme formation. This question is being investigated.

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THE ALKALINE REACTION OF THE DEW ON COTTON PLANTS

SINCE the presentation of a paper by me at the meeting of the American Chemical Society, New Haven, Connecticut, April, 1923, and its publication in the *Journal of Agricultural Research*,[1] under the title "Excretions from leaves as a factor in arsenical injury to plants," two communications upon certain points of this paper have appeared in SCIENCE, which seem to require on my part a few words of explanation.

The first point is one of chemical fact—whether the alkaline earth carbonates are or are not alkaline to phenolphthalein.

Mr. J. E. Mills (SCIENCE, September 19, 1924) states that, "Mr. Smith seems to think that there is something in his analysis of the dew, showing calcium and magnesium carbonates and bicarbonates, to account for the alkalinity observed. Since both acid and normal alkaline earth carbonates are neutral to phenolphthalein this would hardly seem possible." Power and Chesnut (SCIENCE, October 31, 1924) repeat part of this statement in the following words, "Mr. Mills has now noted (*loc. cit.*) that it would hardly seem possible that the alkalinity of the dew can be attributed to these compounds." The words "these compounds" as used are rather indefinite in meaning, but they must refer to the carbonates or bicarbonates or both, since those were the only salts to which Mills' statement applied. It is very easy to show that calcium carbonate, at least, is alkaline to phenolphthalein, as the reagent material, and even Iceland Spar, when powdered, will readily color an aqueous solution of that indicator.

Since calcium carbonate is a salt of a moderately strong base and a very weak acid, it hydrolyzes when dissolved in water, as the result of which the solution contains not only calcium and carbonate ions, but also bicarbonate and hydroxyl ions, the formation of which may be illustrated by the equation $\overset{=}{CO_3} + H_2O = H\overset{-}{CO_3} + O\overset{-}{H}$. The hydroxyl ions so formed are evidently sufficient in number to redden phenolphthalein. The question of equilibrium in solutions of lime and carbon dioxide has been thoroughly treated by Johnston and Williamson.[2]

Mills, after stating that the carbonates and bicarbonates of the alkaline earths could hardly explain the alkalinity, suggested that an alkali carbonate would suffice to do so. As a matter of fact I collected a sample of dew from cotton plants at Tallulah, Louisiana, subsequent to the work reported in my paper, and submitted it to the Insecticide and Fungicide Laboratory, Bureau of Chemistry, in July, 1923, for a more complete analysis than my limited facilities at Tallulah permitted. This sample was analyzed by Mr. J. J. T. Graham, who found potassium present equivalent to 252 parts of K_2O per million. The presence of potassium carbonate in the dew, along with other salts, can therefore be considered possible. In this connection it may be of interest to note an article, which later came to my attention, entitled "Die Secrettropfen an den Laubblättern von *Phaseolus multiflorus* Willd. und der Malvaceen," by A. Nestler.[3] Nestler found that *Phaseolus multiflorus* Willd. and several species of Malvaceae—cotton was not included among those investigated—secreted drops of liquid which were usually alkaline to phenolphthalein

[9] Miller, E. W., *J. Biol. Chem.*, Vol. 48, 329 (1921).
[1] Vol. 26, No. 4, p. 191, October 27, 1923.

[2] *J. Amer. Chem. Soc.*, Vol. 38, No. 5, pp. 975–983.
[3] *Berichte der Deutschen Botanischen Gesellschaft*, Vol. 17 (1899), p. 332.

and which were found to contain carbon dioxide and potassium. On this basis, he considered that potassium carbonate was present, but because the phenolphthalein color was not always marked at first but developed on standing he suggested the possibility that bicarbonate is excreted and changes, by loss of CO_2, to carbonate. He states that with *Phaseolus multiflorus* "a small quantity of calcium carbonate was found."

The second point to be considered is the *cause* of the alkalinity of the dew.

Mr. Mills' assumption, as expressed in the first sentence in the quotation I have made from his article, is correct to the extent that I considered the presence of calcium and magnesium carbonates and bicarbonates to be at least consistent with the alkaline reaction. The statement of Power and Chesnut that I "was led to conclude that its alkalinity was to be attributed to the presence of the bicarbonates of calcium and magnesium" is not in accord with my original article. The only statement made therein concerning this point, which these writers quote in part, was "the dew gave a reaction alkaline even to phenolphthalein, indicating the presence of soluble hydroxide or salts of very weak acids." This statement was made designedly for the very reason that I did not care to express an opinion as to the specific causes of the alkalinity. The carbon dioxide was found by qualitative tests, but its form was estimated by titration as in water analysis and the alkalinity to phenolphthalein was taken as evidence that some of it was present as carbonate.

That other reacting materials are present, Power and Chesnut have proved by demonstrating the existence in the dew of ammonia and trimethylamine. The presence of these compounds is also consistent with the alkaline condition, but as to whether they or the carbonate constituents are the chief cause of the alkalinity is a point still to be determined.

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE SPRING MEETING OF THE EXECUTIVE COMMITTEE

THE regular spring meeting of the executive committee was held at the Cosmos Club in Washington on Sunday, April 26, there being three sessions, which are reported below.

Forenoon Session.—The session came to order at 10:30, with the following members present: Cattell, Fairchild, Humphreys, Kellogg, Livingston, Noyes, Pupin, Ward, Wilson. Dr. Duggar was absent with valid excuse. The following are the main items of business transacted:

(1) Dr. Cattell was unanimously elected permanent chairman of the Executive Committee.

(2) A resolution was adopted heartily favoring the project to establish a National Museum of Engineering in Washington.

(3) On account of the vacancy occurring in the membership of the executive committee, Dr. F. R. Moulton, of the University of Chicago, was unanimously elected to be a member of this committee for the remainder of the present year. (The term of Dr. Humphreys, now general secretary, was to expire at the end of the Kansas City meeting and Dr. Moulton's election is to complete that term.)

(4) On account of the resignation of Dr. F. G. Cottrell as vice-president for Section M (Engineering) and upon due nomination by the section committee, the permanent secretary was instructed to cast the ballot of the executive committee for Dr. C. R. Richards, president of Lehigh University, to be chairman of the section and vice-president for the section for the current year.

(5) There were elected to fellowship 770 members, distributed among the sections as follows: A, 13; B, 51; C, 19; D, 14; E, 113; F, 128; G, 150; H, 6; I, 1; K, 2; L, 2; M, 122; N, 116; O, 33. (No elections to fellowship had occurred for over a year and the section secretaries had been asked to make a study of their section membership lists with the aim of securing the nomination of members eligible to fellowship but not previously elected. The large number of elections at this time was due mainly to the activity of the section secretaries in this connection.)

(6) The permanent secretary was instructed to present to the executive committee by a mail ballot nominations for fellowship that may be duly approved and sent in by section secretaries before the going to press of the new membership directory, now in preparation, to the end that the committee may act on such nominations in time for the records to be corrected before the directory is printed.

(7) The Georgia Academy of Science, the Indiana Academy of Science and the North Dakota Academy of Science were elected to affiliation with the association, on the basis of the new affiliation arrangement adopted at the fifth Washington meeting.

(8) On its application, the American Society of Parasitologists was elected to official affiliation with the association. According to lists supplied by the society, it has 144 members, 88 of these being members of the American Association, including 49 fellows. The society is therefore to have one representative in the association council.

(9) On its application, the History of Science So-

ciety was elected to official affiliation with the association. According to lists supplied by the society, it has 346 members, 207 of these being members of the American Association, including 147 fellows. The society is therefore to have two representatives in the association council.

(10) On its application, the Honor Society of Phi Kappa Phi was elected to official affiliation with the association. According to lists supplied by the society, it has 4,671 members, 352 of these being members of the American Association, including 210 fellows. The society is therefore to have two representatives in the association council.

Afternoon Session.—The committee adjourned for luncheon at 1:15 and reconvened at 3:00, with all the members present excepting Dr. Kellogg, who had presented a valid excuse. Dr. Rodney H. True, secretary of the Committee of One Hundred on Scientific Research, was present by invitation. Business was continued as follows:

(11) Dr. A. E. Kennelly was elected to be the representative of the American Association in the Committee on Scientific and Engineering Abbreviations and Symbols of the American Engineering Standards Committee.

(12) It was voted that the president of the association is *ex officio* chairman of the Committee of One Hundred on Scientific Research, and that membership in that committee be for a term of four years, beginning with the present calendar year.

(13) It was voted that the secretary of the Committee of One Hundred be asked to prepare an evening program on the problems of research for a general session at the Kansas City meeting, President Pupin to preside at the session and make the introductory address.

(14) The committee approved the selection of a speaker for the Sigma Xi lecture, to be given under the joint auspices of the association and the Society of Sigma Xi at the Kansas City meeting.

(15) It was voted that an afternoon general session at the Kansas City meeting be under the joint auspices of the association and the American Mathematical Society and that it be devoted to the third James Willard Gibbs lecture, arranged by the American Mathematical Society.

(16) It was voted that an evening session at the Kansas City meeting be devoted to an address by some distinguished man of science from abroad, and that the general and permanent secretaries be requested to arrange for this.

(17) Arrangements were made for the organization of a committee on exhibitions at the annual meetings.

(18) On invitation of Dr. Duggar, chairman of the organizing committee for the International Congress of Plant Sciences, the executive committee expressed itself as looking with approval upon the proposal to hold sessions of the American Association in connection with the above-named congress, which is to occur at Ithaca, August 16–23, 1926.

Evening Session.—The committee dined together and reconvened for the evening session, with all members present. Business was continued as follows:

(19) The sum of five hundred dollars was appropriated for the American Association table at the Naples Zoological Station, this appropriation to be disbursed from the treasurer's available funds.

(20) The sum of one hundred dollars was appropriated for the National Conference on Outdoor Recreation, from the permanent secretary's funds.

(21) The sum of sixty dollars was appropriated for the American Institute of Sacred Literature, from the permanent secretary's funds.

(22) Dr. Humphreys, chairman of the special committee on publications, presented a report on tentative plans for a popular journal under the auspices of the American Association and also presented a memorandum from Dr. Cattell on the ultimate acquisition of the journal SCIENCE by the association. The memorandum follows:

It is agreed and contracted between the American Association for the Advancement of Science, incorporated in the State of Massachusetts, and James McKeen Cattell, of Garrison, New York, that on the death of the latter or on his relinquishment of the control of the weekly journal SCIENCE for any cause, the journal shall become the absolute and unincumbered property of the association on the following conditions, namely: (1) that the present arrangement between the association and the journal, or some other arrangement adopted by mutual agreement, is at the time in effect; (2) that should Josephine Owen Cattell (who for over thirty years has cooperated in the editorial and business conduct of the journal) survive the acquirement of the journal by the association, she shall be paid annually during her life one half the average net profits of the journal during the five years preceding its acquirement, and (3) that the arrangements for editing, publishing and printing the journal in effect at the time of the acquirement of the journal by the association shall be continued so long and in so far as this is consonant with the interests of the association.

(23) The executive committee unanimously approved of the proposals of the memorandum and authorized the president and the permanent secretary to sign the agreement after it had been put in contractual form. The committee unanimously voted its sincere and hearty thanks to Dr. Cattell for his most generous offer.

The executive committee adjourned at 11:00 p. m., to meet at its regular fall meeting.

BURTON E. LIVINGSTON,
Permanent Secretary